Space Weather Technical Forecast

Issued on Thursday 6 February 2025 at 12:44 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Expected. Increased near-term Chance of S1. Increasing Chance of G1/G2 Geomagnetic Storms into UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured by GOES16 and 18 was Moderate over the past 24 hours, with frequent mid-ranking C-class flares observed that were later trumped by a peak M7.6 at 06/1104UTC from AR3981.

There are now up to twelve active regions on the Earth-facing disc. The northwest remains the dominant quadrant, with a cluster of large and complex regions, with AR3981 remaining the largest. This group saw mixed fortunes in terms of growth in the period, with trailing spot penumbral decay, but conversely some emergence in its central portions, and also the preservation of its Mt Wilson delta spot in its Ehi/Beta-Gamma-Delta classification. The region immediately to its north saw the most marked growth of the period, with strong proliferation of small leading and central spots to become a Eai/Beta-Gamma. The other regions in this northwestern cluster, meanwhile, generally showed slight decay. Other parts of the disc showed minor sunspot development (as in the southwest), else were populated by smaller and stable apparently unipolar groups, as in the east.

At the time of writing, no CME was visible on coronagraphs from the M7.6 flare, however some EUV imagery (e.g. AIA304) does hint in ejecta being released. Relevant coronagraph imagery is awaited.

Prior to this event, apparently minor coronal dimmings perhaps tied to small filament activity near the trailing spots of AR3981 were observed in AIA211 around 05/2030UTC and 06/0530UTC, however no resultant CMEs (Coronal Mass Ejections) were observed. At present, no new CMEs have been identified in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, varied from initial Background conditions to show an enhancement later in the 24 hours to Slightly Elevated solar wind speeds, which rose from 375 to finish near 450. The cause of this enhancement is uncertain, however a glancing interaction with the M4.1-related 02/2320UTC CME from AR3981 was mooted for around this time. ACE EPAM became disturbed in the current UTC morning, but there was no obvious signal identified.

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The solar wind density rose from low single figures to peak around 10ppcc with this speed rise (before falling), hinting at either a transient or a CIR. The phi angle was unchanged in positive orientation (away from the Sun). The IMF initially showed a gradual rising trend from Background levels, rising to a Slightly Elevated peak of 11nT around 06/0330UTC before decreasing in magnitude and becoming more erratic thereafter. The north-south component, Bz, varied between +/-7nT.

The net result of the above solar wind measures was provisionally Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 was at Background levels, however any response from the M7.6 is awaited.

High energy electron flux (greater than 2MeV) at GOES16 was at Normal Background to Moderate levels, peaking at 427pfu at 05/1430UTC. The associated 24-hour fluence persisted below the Active threshold, recording 1.15e7 integrated pfu at 06/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Expected at first, with isolated M-class flares and a Slight Chance of X-class flares, most likely from AR3981 and perhaps now AR3984 in the northwestern cluster.

Solar Wind / Geomagnetic Activity: Up to two CMEs feature in the forecast - firstly the M4.1-related 02/2320UTC CME from AR3981 which is anticipated to pass 1AU imminently, and may in fact be in course as of the time of writing of this guidance as a glancing blow.

The second CME arose from a filament eruption in the southwest from early on 05 February, which has a low chance of delivering a glancing blow late day 2 or day 3 (Friday 07 into Saturday 08 February). Both events are low confidence. The potential for further CMEs and hidden transients is currently elevated but reducing as the main sunspot cluster moves further from the solar meridian.

The next recurrent feature, CH13/-, may then feature on Sunday 09 February, but with some potential to arrive earlier in the UTC weekend given its apparently increased intensity versus last pass, and by inference, increased speed.

There is a peak Chance of G1/G2 Minor/Moderate geomagnetic storm conditions in this four-day period. The first peak is lower confidence but would potentially be of greater magnitude if present, from 08 into 09 February from the 05 February filament. The UTC weekend should then see an increasing Chance of G1 from CH13/-.

Energetic Particles / Solar Radiation: There is now a Chance of S1 from the recent M7.6 flare within the remainder of the current UTC day and perhaps into Friday 07 February. The underlying slight day-on-day rise in risk otherwise remains, as the northwestern sunspot region cluster moves into a better-connecting position with Earth.

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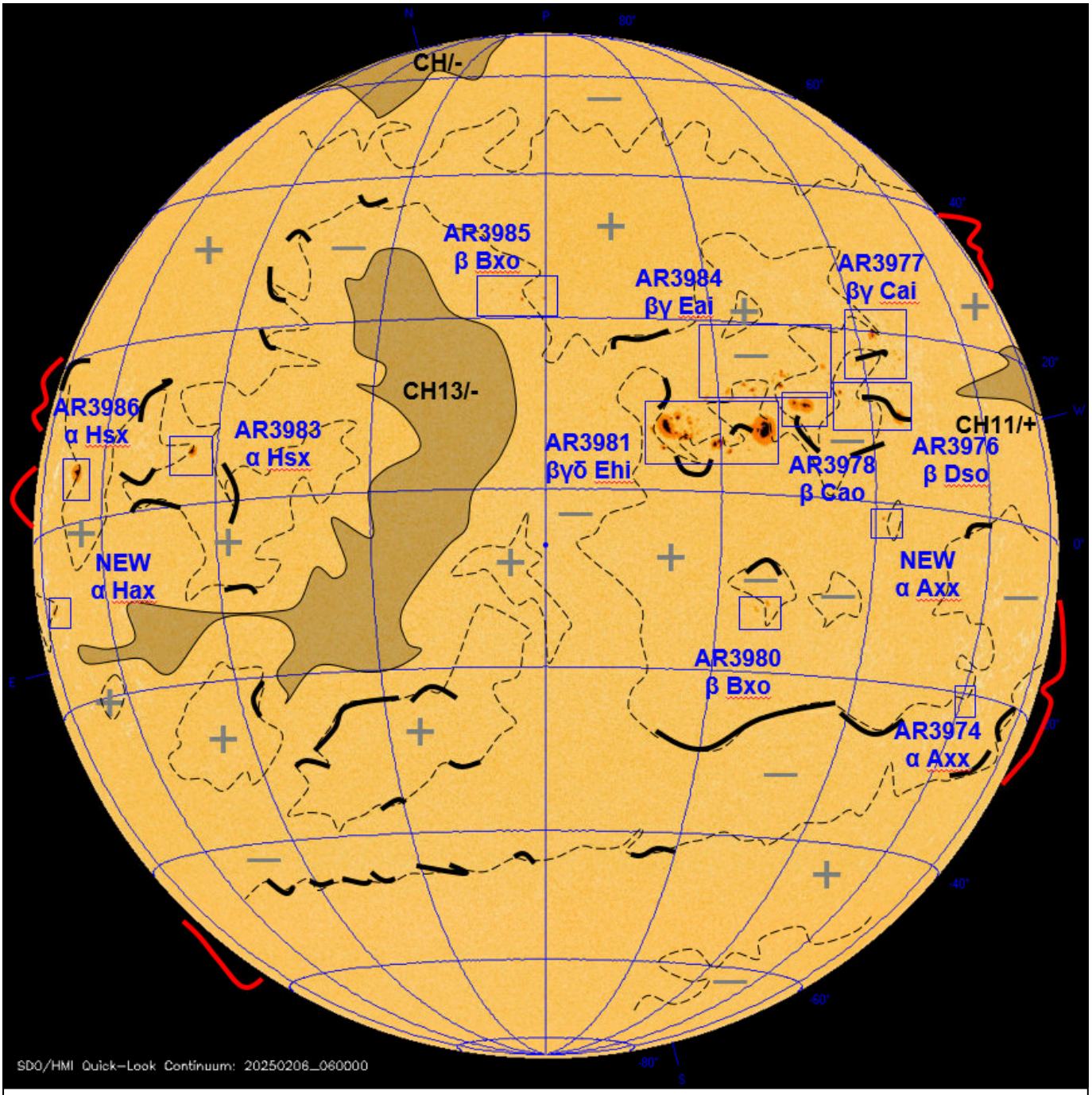
High energy electron flux observed at GOES16 has remained at Moderate peak levels and has perhaps now peaked in relation to CH11/+. Geomagnetic activity and inbound CMEs should mean that there are no further drivers until the new working week in the wake of CH13/-. The corresponding 24 hour fluence is expected to persist below the Active threshold.

Figure 1: Solar synoptic map, valid 06/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Up to two CMEs feature in the forecast - firstly the M4.1-related 02/2320UTC CME from AR3981 which is anticipated to pass 1AU imminently and may be in course as of the time of writing of this guidance as a glancing blow. The second CME arose from a filament eruption in the southwest from early on 05 February, which has a low chance of delivering a glancing blow late day 2 or day 3 (Friday 07 into Saturday 08 February). Given the apparent amount of material which erupted from this filament, should it arrive at Earth it could give a noticeable impact. Both of these events are low confidence.

The potential for further CMEs and hidden transients is currently elevated but reducing as the main sunspot cluster moves further from the solar meridian.

The next recurrent feature, CH13/-, may then feature on Sunday 09 February, but with some potential to arrive earlier in the UTC weekend given its apparently increased intensity versus last pass, and by inference, increased speed. MOSWOC Enlil's solar wind speed is felt to be correct in character, but it persists with an unfeasible early onset of the next high speed stream, (before the end of the UTC working week - this is not the preferred forecast).

All considered, there is a peak Chance of G1/G2 Minor/Moderate geomagnetic storm conditions in this four-day period. The first peak is lower confidence but would potentially be of greater magnitude if present, from 08 into 09 February from the 05 February filament. The UTC weekend should then see an increasing Chance of G1 from CH13/-, with this feature much larger and more intense versus last rotation, which must be considered along with its increasingly potent negative polarity as the equinox approaches.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	5	5	20	50
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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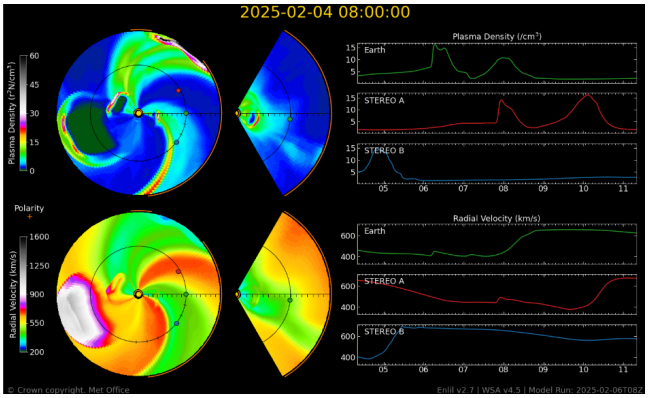
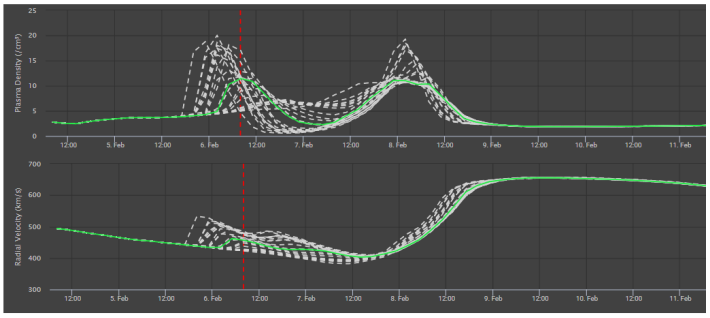
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
03/0457	Partial	AR3981	NE	590	Perhaps arrived/arriving UTC morning of 06 February	Perhaps now peaked.
05/07:00	Partial	Filament	SW	790	08/0000 +/- 6 hours	Low chance of glancing impact.

Figure 2: Latest MOSWOC Enlil run and ensemble, badge time 06/0800UTC, showing up to two inbound CMEs from 02 and 05 February - mainly visible in the ensemble. MOSWOC Enlil's treatment of the upcoming fast wind from CH13/- is felt to be of reasonable magnitude but very likely too early in onset, which will have ramifications should the M7.6 flare have produced any CME (i.e. an overly-short transit time of any new CMEs to Earth).





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Radio Blackouts - X-Ray Flares

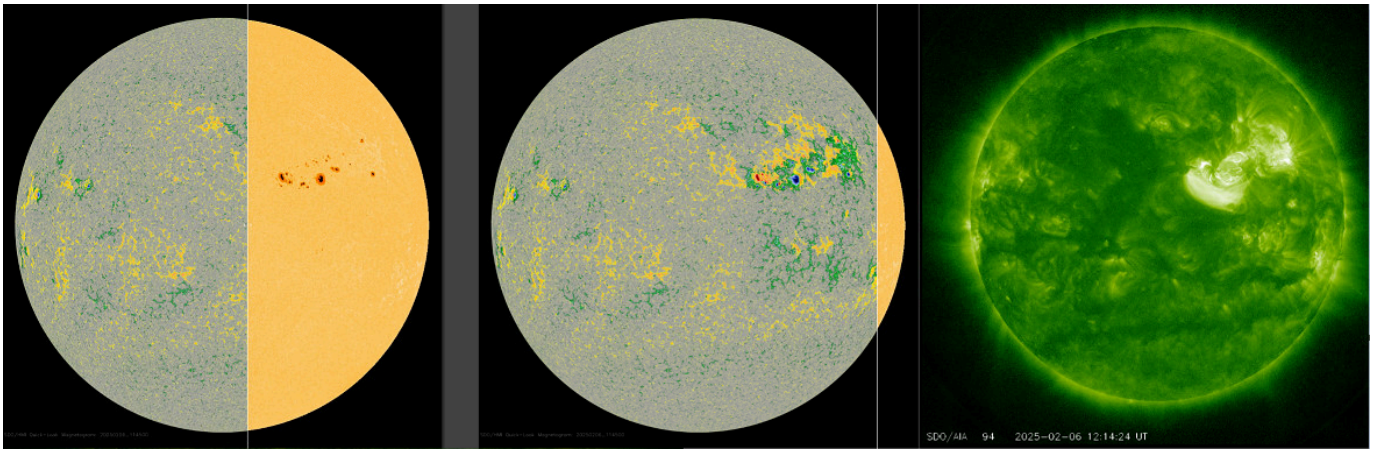
The solar disc has seen a gradual rise in population in the past 24 hours, however this is perhaps deceptive as the new groups are very small unipolar regions. The main sunspot cluster in the northwest had shown some signs of simplifying in the past 24 hours - mirrored in the decreased flare intensity, however this trend was abruptly interrupted by the 1104UTC M7.6 flare from the trailing spots of AR3981 - the source of both the most recent and earlier activity. This group remains a large and complex group with a persistent Mt Wilson delta in its centre, and recent strong growth in AR3984 to its immediate north may complicate the magnetic connections in the area which make it still the main aspect of monitoring.

Regarding the balance of sunspot regions, none of the main front-sided regions depart the disc in the period. Recurrence suggests the potential for one or two returning regions due, perhaps further evidenced by a far-sided southeast-headed CME in the past 24 hours, however far-side helioseismic output has no strong signals for particularly significant groups.

All considered, M-class flares are Expected initially, perhaps becoming Likely into the UTC weekend should the previous apparent simplifying tendency and reduced flare cadence in the main groups resume. X-class flares are rated at a Slight Chance throughout.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	70	70	70
Very Active	R3-R5 (X Class)	No	20	20	20	20

Figure 3: HMIIF, HMIBC and AIA094 imagery at 06/1215UTC in the aftermath of the M7.6 flare from AR3981 in the northwest.



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Solar Radiation Storms (High Energy Protons)

Historical data suggest there is a now Chance of S1 given the recent M7.6 flare from the central region of the disc. This may manifest within the remainder of the current UTC day and perhaps into Friday 07 February - perhaps rising in the next few hours. The underlying slight day-on-day rise in risk otherwise remains as the northwestern sunspot region cluster moves into a better-connecting position with Earth.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	30	25	20	25
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: At the time of writing, the GOES16 X-ray trace's actvity has yet to manifest on GOES18's proton flux counts, and may not do so. The chances of this occurring are greatest in the coming few hours (perhaps 30% chance barring no new flares), before a resumption of the raw risk for the current cohort of sunspot regions resumes.

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 has again peaked at Moderate levels and is on a flat trend, implying that any increases from CH11/+ have probably now been realised at GEO. The next likely charging mechanism for the Van Allen belts is CH13/-, but any subsequent significant rise in electron levels is expected to be beyond the current forecast period. Possible glancing transients in the interim complicate this picture somewhat, but this will most likely result in more frequent Background flux at GEO before any CH13/- effects are felt.

The corresponding 24-hour fluence is expected to persist below the Active threshold. MOSWOC REFM output shows levels well below Active through the next 72 hours, however this will not account for intervening CMEs nor the increased intensity of CH13/-, although the latter mainly falls outside the REFM forecast period. REFM can be considered a good proxy should the inbound CMEs miss Earth in the meantime - i.e. a continuing unremarkable electron trace at GOES16.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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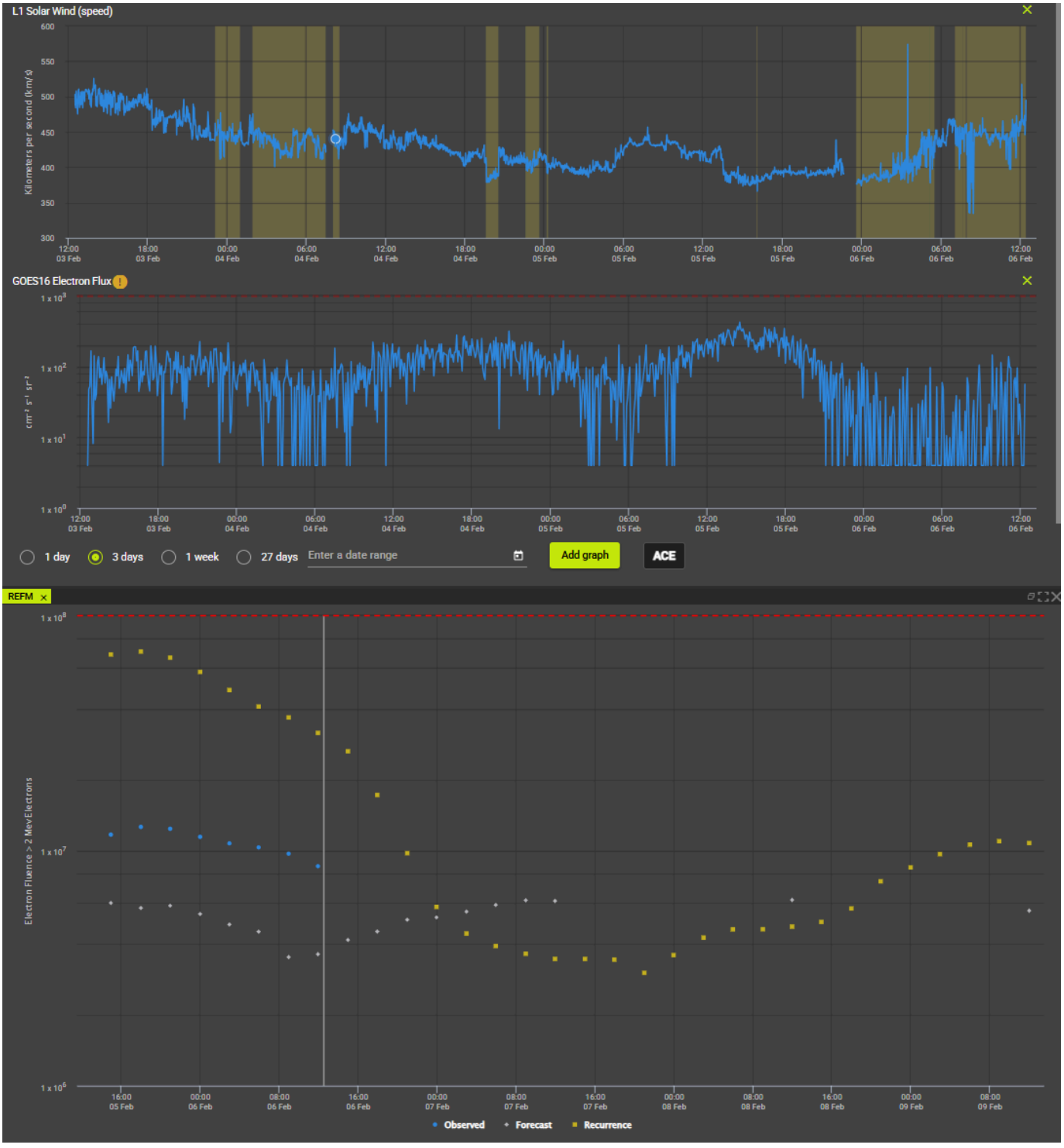
Figure 5: Past 72 hours in L1 solar wind speed (top), in the wake of CH11/+ and with a potential current CME glance in course. The resultant GOES16 high energy electron flux can be seen in the central plot as peaking at Moderate, and this is felt to be the maximum attainable from this coronal hole. MOSWOC REFM is also shown below for completeness, however its thoughts are only valid in the possible absence of CMEs in its 72-hour range.



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